BIOLEACHING OF ZINC USING CASSAVA EXTRACT
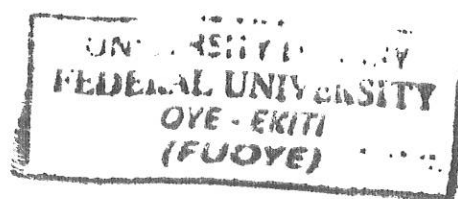
BY

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(MME/11/0420)

A PROJECT SUBMITTED TO THE DEPARTMENT OF MATERIALS AND METALLURGICAL ENGINEERING FEDERAL UNIVERSITY OYE EKITI

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN MATERIALS AND METALLURGICAL ENGINEERING

September, 2016.

CERTIFICATION

This is to certify that the project on the Bioleaching of zinc using cassava extract was carried out by ADEGBENRO, ADEKUNLE EMMANUEL (MME/11/0420) of the department of Materials and Metallurgical Engineering, Federal university Oye Ekiti, Oye Ekiti.

It is entirely my own work and has not been submitted to any other university or higher education institution, or for any other academic award in this university. Where use has been made of the work of other people it has been fully acknowledged and full referenced.
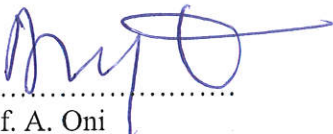
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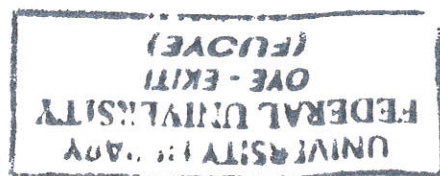
DEDICATION

I dedicate this project to the my loving parents, Mr. and Mrs. Adegbenro and siblings

ACKNOWLEDGMENT

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CHAPTER ONE

1.0   INTRODUCTION

1.1   BACKGROUND STUDY

The project work is based on using bio-leachant from cassava fluid to extract zinc from its ore unlike the most cases where inorganic leachants such as concentrated, HCl and other bases are used.

Zinc Ore is usually mined below the surface of the ground, sphalerite which the principal mineral is zinc is always found alongside with galena which is for leadextraction. Some other zinc containing mineral include hemimorphite, hydrozincite, calamine, frankline, smithsonite, willemie and zincite. In Nigeria, large complex ore of lead and zinc complex associate are found at Abakaliki, which level of exploration and exploitation is far below the reality. The ore is only mined for export leaving the local industries which may need the final products to suffer. The after effect is that zinc products such as galvanized steel sheet are very expensive for common man.

Ore beneficiation which includes the crushing and grinding of the zinc ore which can be done using various machines such as jaw crusher, gyratory crusher, pulverizer, ball mill etc. to reduce the size of the zinc ore. The extraction of zinc by conventional methods using active acids, bases and cyanides have been reported in the literature. Nonetheless, literatures are very scarce on the use of bioleaching of zinc using the available agrocyanide. Fortunately, Nigeria has vast area of land suitable for agriculture where very large quantities of cassava are produced annually. It has been known that cassava plant is a reliable source of agro-cyanide. Hence, there is need to exploit the opportunity in the extraction of zinc. The extraction of zinc from its ore using the cassava fluid entails some common basic steps of comminution and separation methods.

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Froth floatation involves the use of the fine size or the Zinc Ore neglecting the coarse size for the ease of leaching. These processes are carried out using Denver D.12 Sub-aeration machine to obtain the froth separated from the tailing. Roasting of the froth in air at about using resistance furnaces to convert the ZnS to ZnO and the leaching of the roasted ore in the cassava leave extract. The extraction is quantify using atomic absorption spectrometric analysis method.

1.2 AIM AND OBJECTIVES

The aim of the research is to extract zinc concentrate from its ore using cyanide from cassava plant.

This research is carried out with the following specific objectives are to:

1. Leach Zinc Ore in cassava fluid extract.
2. Determine the amount of metal dissolution in the cassava fluid extract.

1.3 STATEMENT OF PROBLEM

Much studies have be undertaken on the extraction of other metals such as Gold and Silver using cyanide or agro cyanide fluid, on the other hand information are very scarce on the use of agro cyanide or bioleachant in the extraction of Zinc.

Also many studies have been undertaken on the extraction of zinc using leachants such as H_2SO_4, HCl whereas little or no work has been conducted using natural organic leachant such as cassava fluid for the extraction process. Hence the current study is undertaken on bioleaching of Zinc using cassava fluid.

1.4 JUSTIFICATION

Zinc Ore to be used in these process are largely available the environment whereas there is shortage of Zinc and high price of galvanized materials in the market, also the cassava fluid is available in every state in the country whereas there is high cost of conventional cyanide used (as a result of importation) in the extraction process will be reduced.

1.5 SCOPE OF RESEARCH

The work covers the comminution processes such as crushing and grinding of the sphalerite using pulverizer and ball mill respectively, particle size analysis using deferent sieve size and mechanical sieve shaker machine for the distribution of the grinded ore, concentration of the ore by froth floatation method using Denver D.12 Sub-aeration machine, Roasting of the froth in air at about using a Resistance Furnaces and leaching in Agro Cyanide (Bio-leachant) obtained from cassava leaves.

1.6 LIMITATION

More tests such as XRD, AAS would have been conducted to characterize the extract but due to non-availability of facilities and processing equipment reduces the work range. In the course of varying parameter during roasting, some the froth could have been heated at different temperature before leaching.

Also in the course of froth floatation much chemical might have be varied to compare the outcome, due to shortage of time the bioleaching would have been done for longer time to observe and compare the result.

CHAPTER TWO

2.0   LITERATURE REVIEW

2.1   GENERAL EXTRACTION PROCESS FOR ZINC

Both hydrometallurgical and pyro metallurgical methods have been used for extraction of zinc from ore or residual (Chen et al., 2009). Recently there are some reports stating that zinc oxide ores can be treated by flotation (Onal et al., 2005; Ejtemaei and Irannajad, 2008; Irannajad et al., 2009; Ejtemaei et al., 2011) and by biohydrometallurgical methods (Meshkini et al., 2011b). Although the results obtained by these methods showed that the efficiency is comparable with usual methods the technology certainly needs further follow-up.

Many studies on leaching of zinc oxide ores by acid and basic solution have been published. In recent years the leaching of zinc ores containing oxidized minerals such as carbonates or silicates with sulfuric acid and its kinetics have been investigated. He et al. (2010) Cun-xiong et al. (2010) and Xu et al. (2010) focused on pressure leaching. The amount of zinc extraction in sulfuric acid solution is high in comparison with other methods and the concentration of silica and other unwanted elements are low. In these studies, the effects of temperature, concentration of sulfuric acid, ore particle size, air pressure, leaching time and solid to liquid ratio were investigated and optimum conditions were established. Espiari et al. (2006) studied the zinc dissolution kinetics of smithsonite and hemimorphite in the lead flotation tailings by sulfuric acid. Zhao and Stanforth (2000) produced zinc powder by use of the alkaline leaching process on smitsonithe. They extracted over 85% of both Zn and Pb, and less than 10% of aluminum using 5 M NaOH solution as a leaching agent in which zinc, lead and aluminum come into solution as Zn (OH)4–2, Pb (OH)4–2, and Al(OH)4–1. Similarly to this study Chen et al. (2009) investigated the parameters affecting the process like ore particle size, temperature,

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leaching time, alkali concentration and solid to liquid ratio to leach refractory hemimorphite [$Zn_4(Si_2O_7)(OH)·H_2O$] zinc oxide ores with NaOH solution. The optimum conditions determined were: particle size of 65–76 μm, 2 h leaching time at 85 °C in the presence of 5 mol/dm3 sodium hydroxide and solid to liquid ratio of 1:10. The maximum zinc extraction in optimum conditions was reported to be 73% of zinc content of ore. Ju et al. (2005) studied the dissolution kinetics of smithsonite ore in ammonium chloride solution. The effect of stirring speed, ore particle size, reaction temperature, and concentration of ammonium chloride on zinc dissolution rate was investigated. The results showed that at the optimum leaching conditions about 91.2% of zinc could be recovered under conditions: ore particle size of 84–110 μm; reaction temperature of C, 240 min reaction time and ammonium chloride concentration 5 mol/dm3.

Traditionally, zinc was produced from ZnS or sphalerite using Roasting, Leaching and Electrolysis (RLE) method. During that process, that is unwanted for the enviroment was produced. Direct Atmospheric Leaching and pressue leaching are two newer methods with a similar approach, except that pressure leaching is caried out under high pressure. In both processes zinc is leached by two reactions, once with ferric ions (Fe^{3+}) and simultaneously during the reaction with. Required ferric is produced via reaction of ferrous ions (Fe^{2+}) and oxygen (Svens et al.,2003). Using these processes there is no more SO2 produced and so they are more environmentally friendly; but they are not still economical, because of oxygen consumption that is relatively an expensive material. Also elemental sulphur produced is impure and so is not easily usable. In order to overcome these limitations bioleaching was proposed. Actually some special bacteria have the ability to oxidize elements such as iron and sulphur. In this process iron is oxidized with these bacteria to produce ferric ion and sulphur is oxidized to

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produce acid. So sulphur would be used during the process again. Also gaseous oxygen is not required because the bacteria would carry out the Fe oxidization and they just need air to respire. However this mechanism is slower than chemical leaching using acid. Equations 1-4 show the reactions (Mousavi et al.,2009).

Proposed a combined technique for bioleaching in two steps: Partial bioleaching of zinc concentrate at the first step followed by chemical leaching of the residue. Using this process less total oxygen was consumed and less elemental sulphur was produced due to the first step and it took less time to leach the zinc due to the chemical leaching step. It was also found that more zinc was extracted due to the two-step process (Souza et al., 2007).

2.2   WHAT IS BIOLEACHING?

Bioleaching is referred to as mobilization of the ions from ores using biological oxidation reactions. Generally, this method is used to extract valuable metals such as copper, zinc, nickel and gold from complex, resistant, low grade and less pure ores. In these decades, there has been increased attention to bioleaching, because of its less cost and being environmentally friendly.

2.3   HISTORY OF BIOLEACHING

Role of microbial processes in mineral dissolution was not recognized till late 1900s. However, natural leaching of metals from rocks was reported even as early as 20-70 AD. Georgius Agricola (1494-1555) referred to copper leaching from ores and leachates from mines. The history of bioleaching begins much earlier than one might ponder. In china and India, natural recovery of copper and other base metals such as zinc from solutions emanating from rocks was

known almost 2000 years ago. The Rio Tinto in Spain owes its nomenclature to the presence of reddish brown water having higher concentrations of ferric ions. Natural iron and copper dissolution from minerals through activity of native microorganisms was later recognized at RioTinto. The contribution of sulfur and iron-oxidising *Acidithiobacillus ferrooxidans* in generating ferric-ion containing sulfuric acid which can dissolve minerals such as copper sulfides was scientifically established in 1947. Since the 1950s research activities on the use of *Acidithiobacillus* picked up and commercial applications of bioleaching particularly in copper dump and heap leaching began to emerge.

2.4   ZINC METAL AND ITS ORES

Zinc, which is a shiny, bluish-white metal and never found pure in nature, is one of the most important base metals in the galvanizing, cosmetic, die casting and manufacturing industries. Zinc is extracted mostly from zinc sulfide ores. Zinc minerals are generally associated with other metal minerals, the most common associations in ores being zinc-lead, lead-zinc, zinc-copper, copper-zinc, zinc-silver, or zinc only. Zinc also occurs in combination with sulfur in a mineral called zinc blende or sphalerite (ZnS) which is its primary source and provides about 90 percent of zinc produced today. Other zinc-containing minerals include hemimorphite, hydrozincite, calamine, franklinite, smithsonite, willemite, and zincite. Zinc ore is mined in about 50 countries, with approximately one-half the total coming from Australia, Canada, Peru, and the USSR. Zinc sulfide ores especially sphalerite are suitable and useful sources for the production of zinc because they could easily be separated and concentrated by flotation from the gangue (Espiari et al., 2006).

2.5   CASSAVA PLANT SPECIES (Manihot esculenta Crantz, Euphorbiaceae)

The cassava is an important component in the diets of more than 800 million people around the world (FAO, 2007) and is the third largest carbohydrate food source within the tropical regions, after rice and corn (Ceballos *et al.*, 2004). Cassava is one of the major staple food plants in the world, utilized by approximately 300 million people (Siegler and Pereira, 1981). Although it originated in South America, cassava has been widely cultivated throughout the tropics for human consumption, animal feed and the starch industry. Philips (1982) reported that the plant was introduced into Nigeria and other parts of West Africa by the Portugese but was unknown in the north of the Niger until 1914(Purseglove, 1968). It has now almost become one of the most important staple food crops of the inhabitants in Nigeria

Figure 1.1   Cassava (*Manihot esculenta* Crantz)

The species of cassava cultivated for food in Nigeria is Manihot esculenta. There are several thousand varieties of cassava and about 100 related wild species (Hershey *et al.*, 1997), with hydrogen cyanide (HCN) contents of their roots ranging from 1-1550 parts per million (ppm) (Cardoso *et al.*, 2005). Cassava plants are generally categorized as bitter or sweet, depending upon their cyanide content. It contains two naturally occurring, but potential toxic compounds called cyanogenic glycosides which releases hydrogen cyanide (HCN) as a result of enzymatic hydrolysis following maceration of the plant tissue, - linamarin and lotaustralin, the former being present in much larger quantities, usually up to 90% of the total. The low-HCN, or sweet cassava, has less than 50 ppm of cyanogenic equivalents, while the high-HCN, or bitter cassava has more than 100 ppm (Wilson and Dufour, 2002). According to Adepoju *et al.*, (2010), the food value of cassava is greatly compromised by its toxic hydrogen cyanide content. The sweet cassava can be cooked and eaten as they are, while the bitter cassava needs to be processed before being consumed.

A large amount of variation exists among the cassava leaf, stem and root characteristics. These characteristics, which include leaf morphology, stem colour, branching habit and storage root shape and colour, may influence cassava yield (Ntawuruhunga and Dixon, 2010). Other, not so obvious, characteristics include resistance to insect pests and diseases. The normal range of cyanogen content of cassava tubers fall between 15 and 400mg hydrogen cyanide (HCN)/kg fresh weight.

The roots are detoxified by hydrolysis of the cyanogenic glycosides and subsequent elimination of the liberated HCN. Contact between enzyme and substrates only occur when the tissues are mechanically damaged or there is loss of physiological integrity, such as during post-

harvest deterioration or wilting of the leaves. In Nigeria, detoxification is partly achieved by cutting into slices, grating or pounding the cassava roots that lead to cell rupture. The HCN content of cassava tubers can be reduced by drying, boiling and fermentation.

The cassava (*Manihot esculenta* Crantz) is cultivated mainly in the tropic and sub-tropic regions of the world, over a wide range of environmental and soil conditions. It is tolerant of insect pests and diseases, and is very tolerant of drought and heat stress. The cassava is not a labour intensive crop and produces well on marginal soils. In many of the cassava growing regions of the world, however, the cassava does not achieve its yield potential, due primarily to disease and limited inputs such as fertiliser and irrigation (Siritunga and Sayre, 2004). Estimates of the Food and Agriculture Organisation of the United Nations (FAOSTAT, 2011) put world production of cassava at more than 230 million metric tonnes annually. Major producers of cassava include Nigeria (37.5 million tonnes per annum), Brazil (24.5 million tonnes) and Thailand (22.0 million tonnes). For the Caribbean region, annual production is in excess of 1.2 million tonnes, with The Bahamas contributing about 240 tonnes to this figure.

Cassava is referred to as a food security crop (Barratt *et al.*, 2006), which can be left in the ground for extended periods of up to two years, until required. It is used mainly as a fresh food item, but is also processed into various food and non-food products, such as starch, flour, beverages, animal feeds, biofuels and textiles.

There is much variation in the nutrient quality of the cassava root (Chaves *et al.*, 2005). In the tropical regions, cassava is the most important root crop and, as a source of energy, the calorific value of cassava is high, compared to most starchy crops (Okigbo, 1980). The starch content of the fresh cassava root is about 30%, and gives the highest yield of starch per unit area of any crop known (Tonukari, 2004). The protein content is extremely low, however, and ranges

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between 1-3% (Buitrago, 1990). The cassava root contains a number of mineral elements, in appreciable amounts, that are useful in the human diet. The root contains significant amounts of iron, phosphorus and calcium, and is relatively rich in vitamin C (Enidiok, *et al.,* 2008).

A proper understanding of these variations in plant characteristics would assist the selection of cassava types with the desired traits.

This, in turn, will contribute to improved crop establishment and increased yields. Among the objectives of the root and tuber crops programme at the Gladstone Road Agricultural Centre are to identify high yielding cassava varieties, to evaluate and preserve cassava germplasm and to provide good quality planting material for local farmers. However, very little documented information on the performance of cassava on the calcareous soils of The Bahamas, under improved agronomic practices, is available. With this present study, efforts are being made to evaluate existing varieties and new introductions for their yield potential under local conditions. Cassava production in The Bahamas could be improved through the introduction of improved varieties and the adoption of improved agronomic practices.

CHAPTER THREE

3.0   METHODOLOGY

3.1   CHARACTERIZATION OF ORE

As-mined complex lead-zinc sulphide ore sample was procured from minerallex ltd. Abakaliki in Ebonyin state. The ore was chemically characterized using atomic absorption spectrometry (ASS) method.
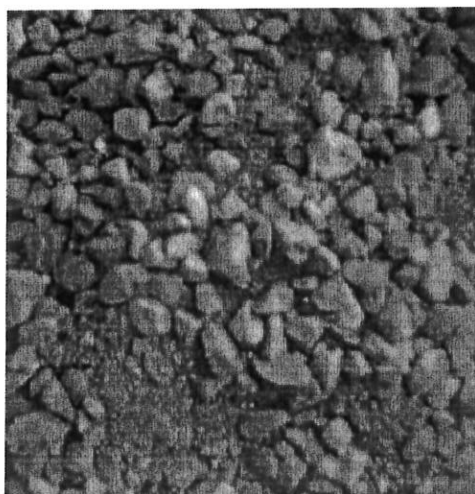
Figure 3.1: Sample of Sphalerite (zinc sulphide)

Table 1.0 Chemical analysis of ore using atomic absorption spectrometer

Metals	Zn	Pb	Cu	Fe	Ni	Sb	As	Au
Conc.ppm	785.91	345.62	69.4	152.56	30.3	50.31	42.1	60.4
Metals	V	Co	Ag	K	Al	Ca	Cd	
Conc.ppm	3.89	3.16	17.65	351.3	791.5	59.4	58.73	

3.2   COMMINUTION (CRUSHING AND GRINDING)

1500g of the as-mined ore was crushed and ground by using the pulverizer and ball mill respectively (figure 3.4 and 3.2). The ore was sieved and separated to -125+75μm particle sizes

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and -800+150 µm particle sizes using a set of eight sieve apertures(850, 600, 425,300,150,125,106,75 and pan) as shown in Table 4.0. Taking 1000g of -125+75 µm (regarded as fine size) for froth floatation.

Figure 3.2: Ball mill machine

Figure 3.3: Steel balls in the ball mill machine

Figure 3.4: Pulverizer

3.3   FROTH FLOATATION

1000g ore was weighted and separated by froth flotation using Denver sub-aeration floating machine (figure 3.5), at 40% pulp density while methyl-isobutyl-carbinol is used as frother and sodium oleate was used as the collector, and calcium oxide is used as the ph regulator. Sphalerite ZnS was recovered as concentrate while the impurities were depressed as tailings.

Figure 3.5: Denver sub-aeration floating machine

Figure 3.6: Flotation of sulphide ore using Denver sub-aeration floating machine

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3.4   ROASTING

250g of -125+75 μm (regarded as fine size) concentrate was roasted to a constant weight in a resistance furnaces at 700-800°C for 3hrs under air atmosphere (Figure 3.7a). The ore was removed from the furnaces and cooled at a room temperature and reweighed. The weight loss method was used to assess the volatile matter content of the ore (Table 3).

Figure 3.7: (a) Observing the heating temperature and (b) cooling at normal atmosphere

3.5   BIOLEACHING USING CYANIDE FROM CASSAVA EXTRACT

The leachant (cyanide) gotten from a cassava leaves(*Manihot esculenta* Crantz) in Ikole Ekiti opposite Federal University Oye Ekiti, Ikole campus was prepared into four different plastic cylinders at 15ml gauge. 5g of roasted ore was distributed into the plastic cylinders at various leaching time (i.e. 7day, 14day, and 21days). To determine the amount of Zn, Pb, Ni, Cu and Fe that dissolves at due date after taking it for chemical analysis using Atomic absorption Spectrometer (AAS).
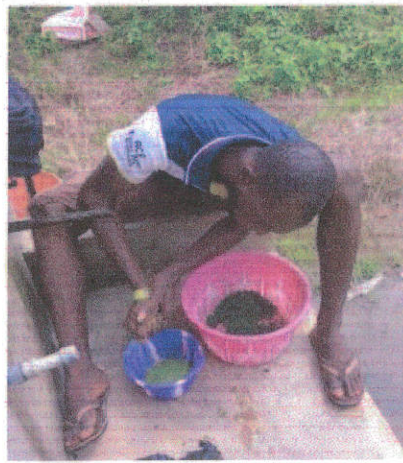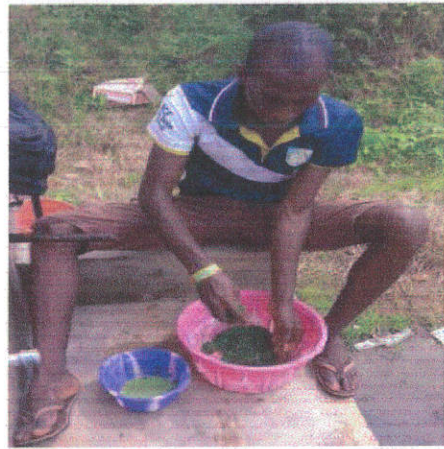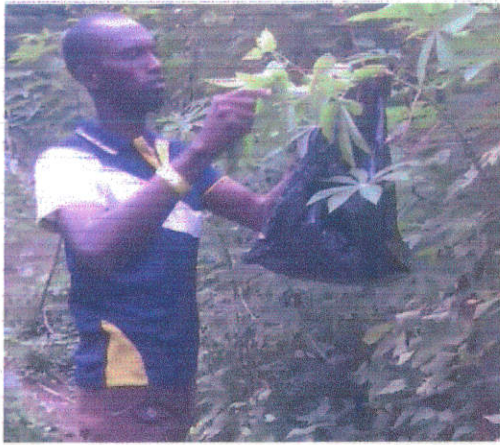
Figure 3.8: (a) Obtaining of cassava leaf (b) squeezing of the cassava leaf and (c) extraction of liquid

Figure 3.9: leaching container   Figure 3.10: Weighing of the roasted ore
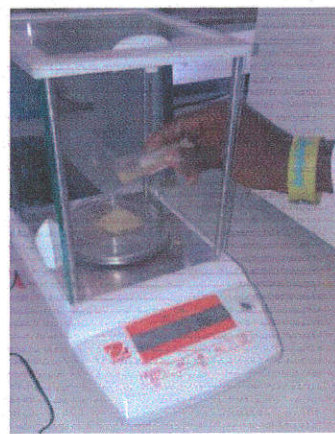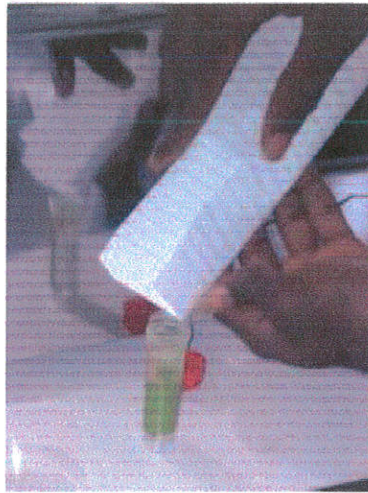
Figure 3.11: pouring of roasted ore
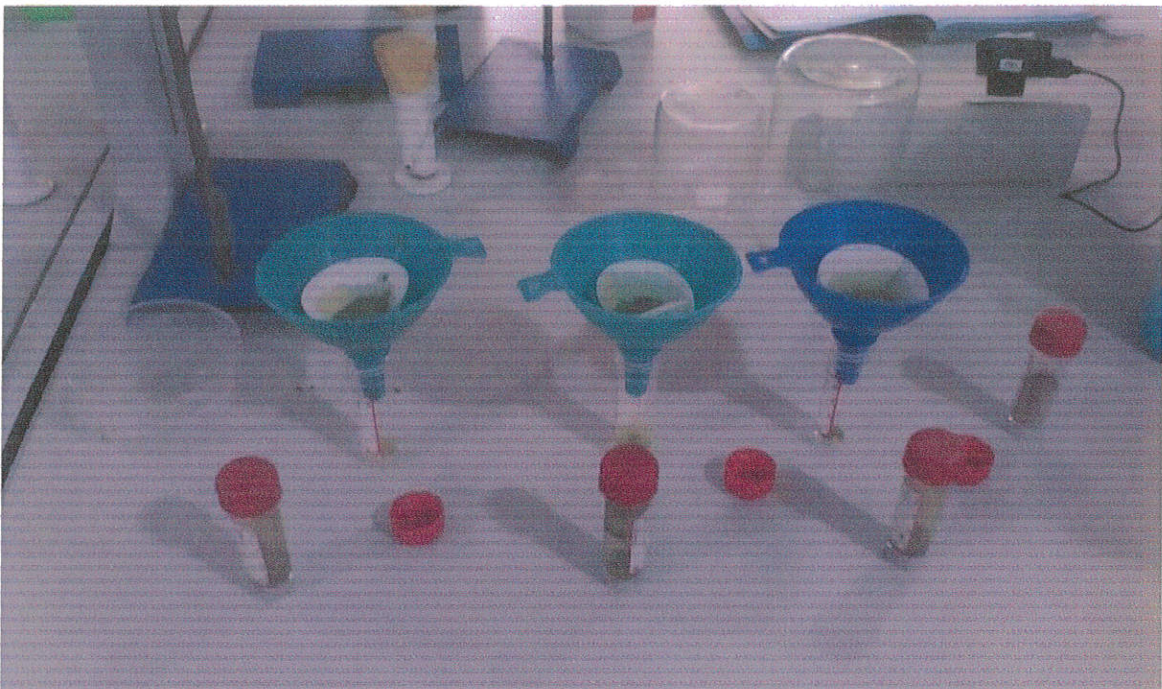
Figure 3.12: Extraction of the Fluid

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│      SPHALERITE (ZINC SULPHIDE)          │
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                    │
                    ▼
┌─────────────────────────────────────────┐
│  COMMINUTION (CRUSHING AND GRINDING)     │
└─────────────────────────────────────────┘
                    │
                    ▼
        ┌───────────────────────┐
        │      FLOATATION        │
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        │       ROASTING         │
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        │      BIOLEACHING       │
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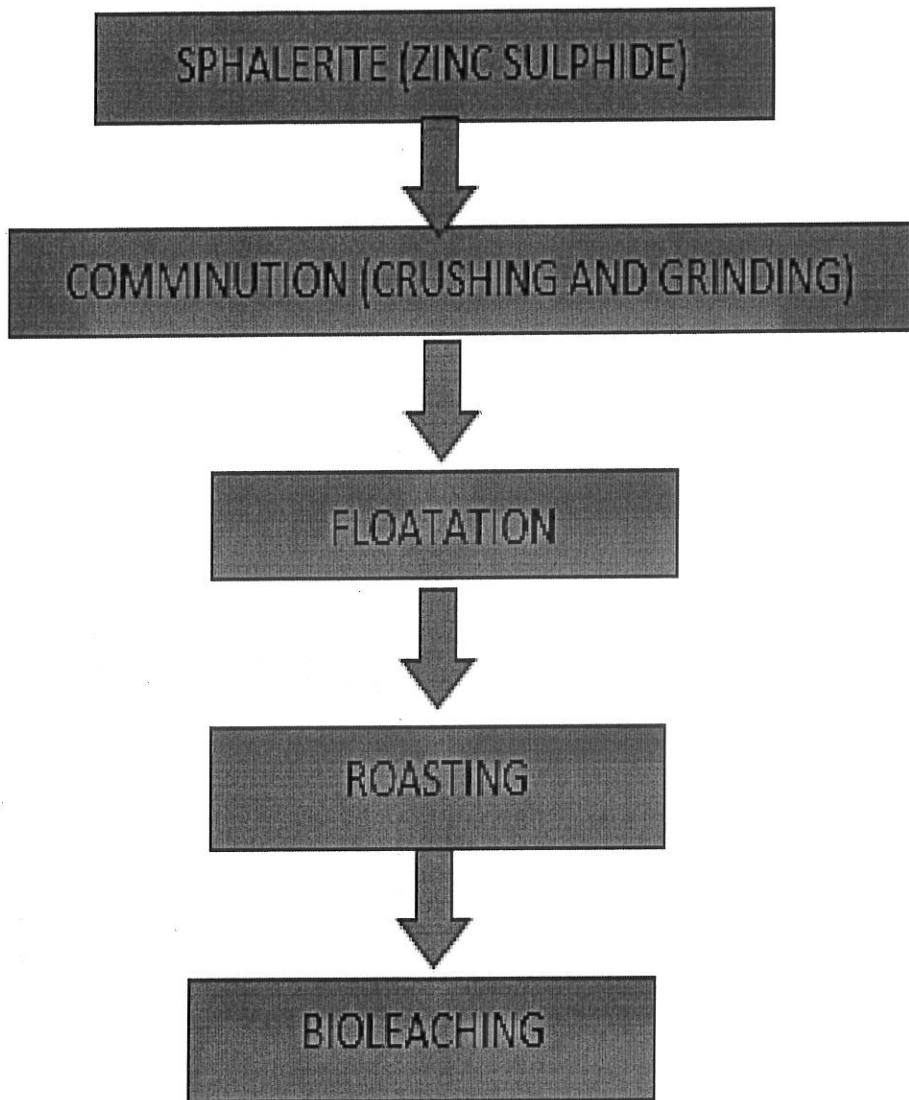
Figure 3.13: FLOW CHART FOR EXTRACTION PROCESS

CHAPTER FOUR

4.0   RESULT AND DISCUSSION

4.1   COMPOSITION OF SPHALERITE SAMPLE

The Figure 4.1 shows that Sphalerite gotten from Abakaliki-Ishiagwu complex zinc sulphide Ore contain the following metals Zn,Pb,Cu,Fe,Ni,Sb,As,Cd,Au,V,Co,Ag,K,Al,Ca also showing their various composition which indicate that the sulphide Ore is rich in Zinc(Zn)and contain little amount of lead(Pb) which are the two major metals required.
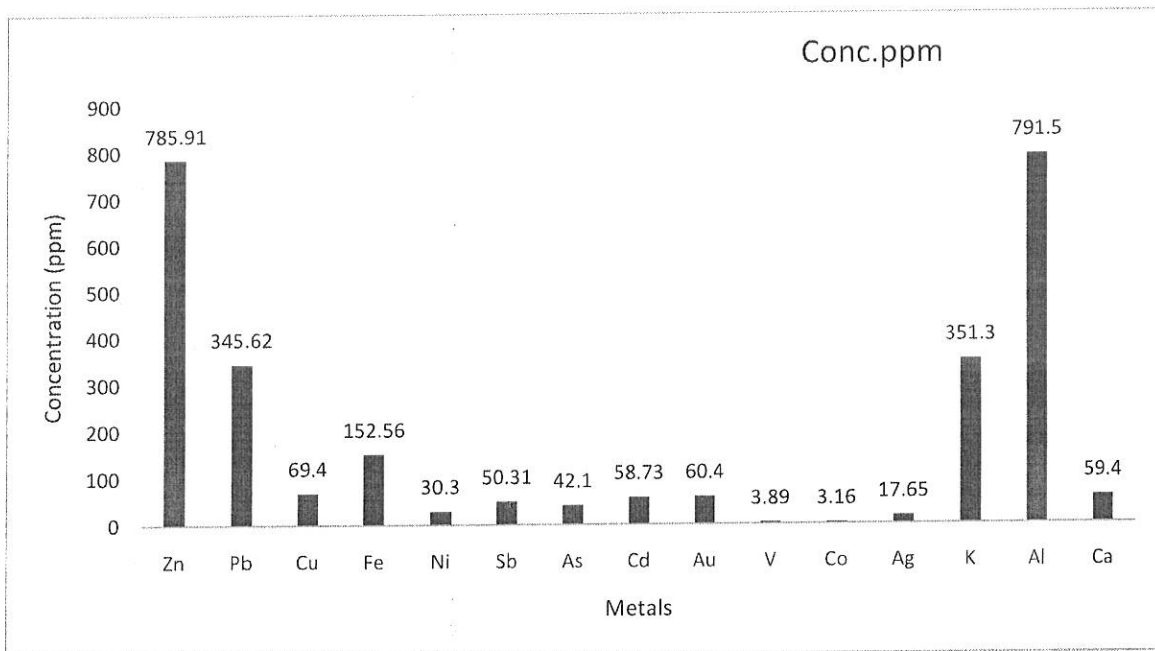
Figure 4.1: Chemical composition of Abakaliki Sulphide Ore.

4.2   Results of the crushing and grinding

The Figure 4.2 shows the result of the crushing and grinding using pulverizer and ball mill respectively, it also indicate the fine size particle(ranging from +850 to -300) and coarse size

particle(ranging from +150 to -75) after grinding. The fine size particle was used for the froth floatation because the surface is more exposed for reaction to occur compare to the coarse size particle.

Table 4.1: Particle Size analysis of Zinc Ore

| Particle size ranges (μm)	Sieve fractions Wt.(g)	Weight (passing) (g)	Cumulative (%)	
			Undersize (%)	Oversize (%)
+850	117.89	7.89	92.11	97.89
-850 +600	12.84	0.86	91.25	8.75
-600 +425	13.22	0.88	90.37	9.63
-425 +300	14.98	1.00	89.37	10.68
-300 +150	144.65	9.68	79.67	20.31
-150 +125	214.68	14.37	65.32	34.68
-125 +106	225.75	15.11	50.21	49.79
-106 +75	270.79	18.12	32.09	67.91
-75	479.34	32.08	0.01	99.99
Total	1494.14			

The Table 2 shows that the mineral is soft for it to produce the large amount of fine particles size unlike crushing of rock or other tough mineral. Also the line indicates that the mineral is reducing in size with respect to the time of grinding.

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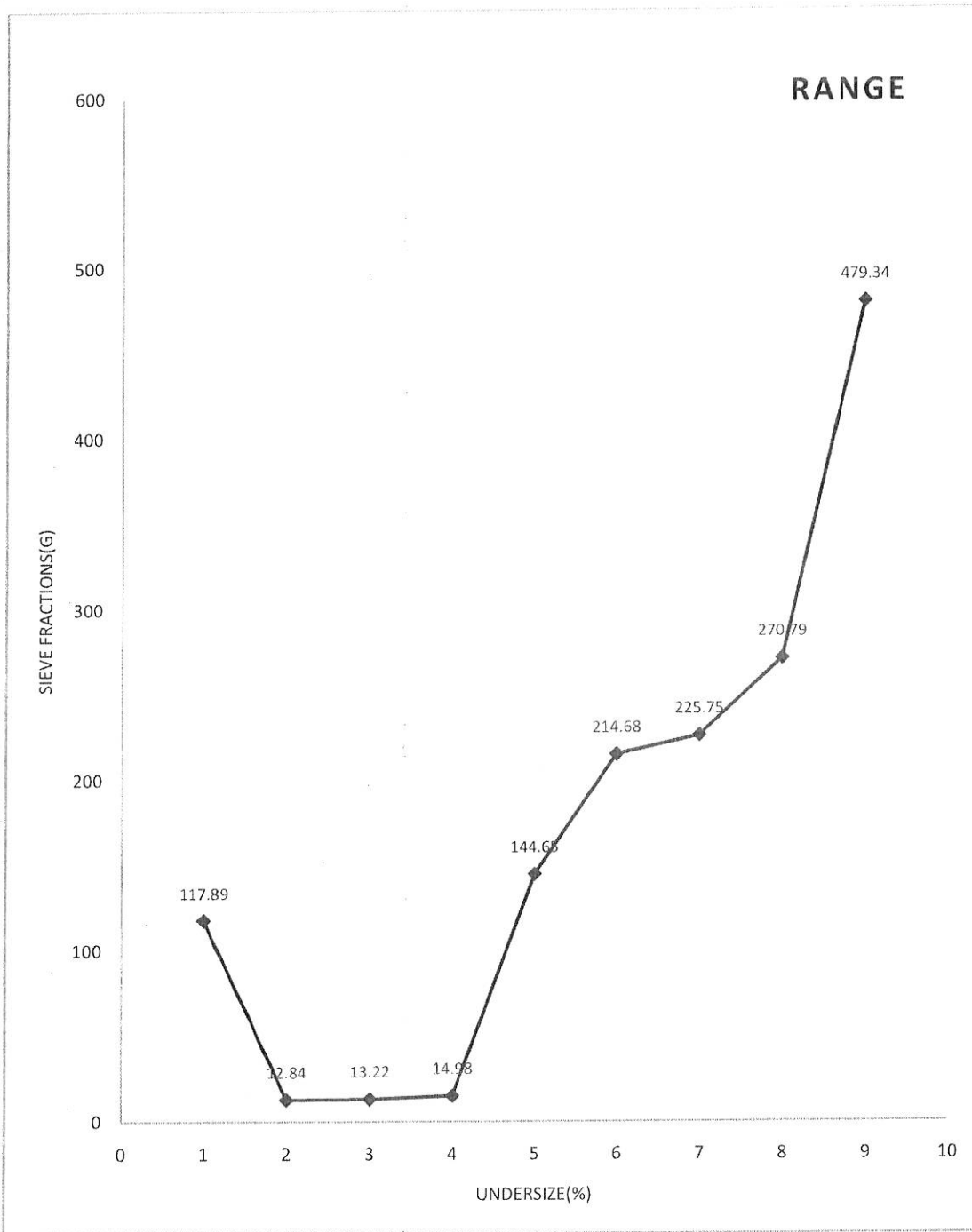
Figure 4.2: Particle Size analysis of Zinc Ore

4.3   Result of froth floatation

Table 4.2: Froth floatation at 40% pulp density.

	Charge(g)	concentrate		Tailings		Loss	
		Wt.(g)	Wt (%)	Wt.(g)	Wt (%)	Wt.(g)	Wt (%)
Run 1	1000	357	36	595	59	48	5
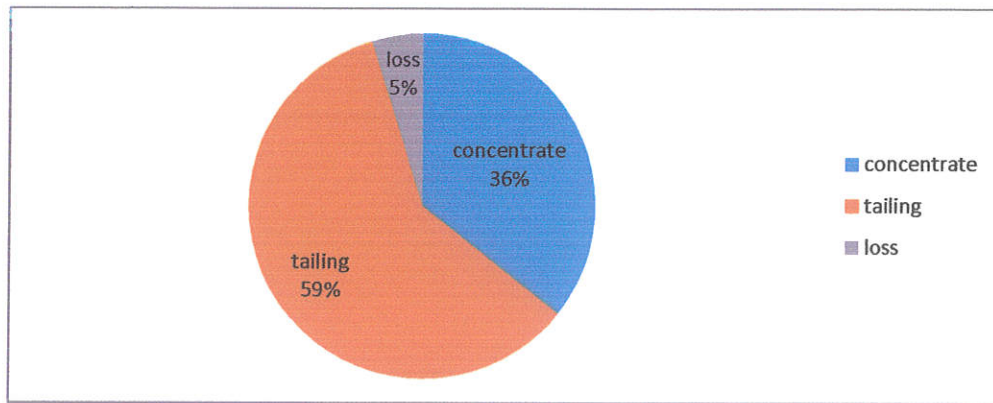
Figure 4.3: Amount of concentrate, tailing and the percentage loss

The Figure 4.3 shows the amount of concentrate received, the tailing as well as the percentage loss in the process. The chart shows that the tailings is more at 59%, the concentrate is 36% and the loss is 5%. The loss occur as a result of some froth sticking to the surface of the container and during decanting before oven drying spillage also occurred.

4.4 Result of roasting of zinc ore

Table 4.3: Roasting of the fine ore concentrate.

| Particle size	Initial wt. (g)	Final wt. (g)	Wt loss (g)	%Volatile matter
(-125+75μm)	250	228.52	21.48	8.99

The amenability of the ore to roasting is presented by the fine particle size used in the work. The roasting released about 8.99% volatile matters (Table 4.3). Roasting method is used to convert the sulphide zinc ore to its oxide, by SO_2 eliminating some of other elements with volatile oxides such as As_2O_3, Sb_2O_3, as shown in the reactions (1-3) below.

$$2ZnS_{(s)} + 3O_{2(g)} = \quad 2ZnO_{(s)} + 2SO_{2(g)} \qquad [1]$$

$$ZnS_{(s)} + 2O_{2(g)} = \quad 2ZnSO_{4(s)} \qquad [2]$$

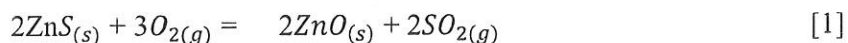$$2As_{(s)} + \frac{3}{2}O_{2(g)} = \quad 2As_2O_3 \qquad [3]$$

Table 4.4: Result of extraction of metals from zinc ore using cassava fluid extract

Leaching time	Zinc (ppm)	Lead (ppm)	Copper (ppm)	Nickel (ppm)	Iron (ppm)
7days	150.25	55.25	3.75	0.00	25.25
14days	149.50	62.25	1.25	0.00	6.00
21days	149.25	79.25	0.25	0.00	4.25

Table 4.5   Result of extraction of Zn from ore using cassava fluid extract

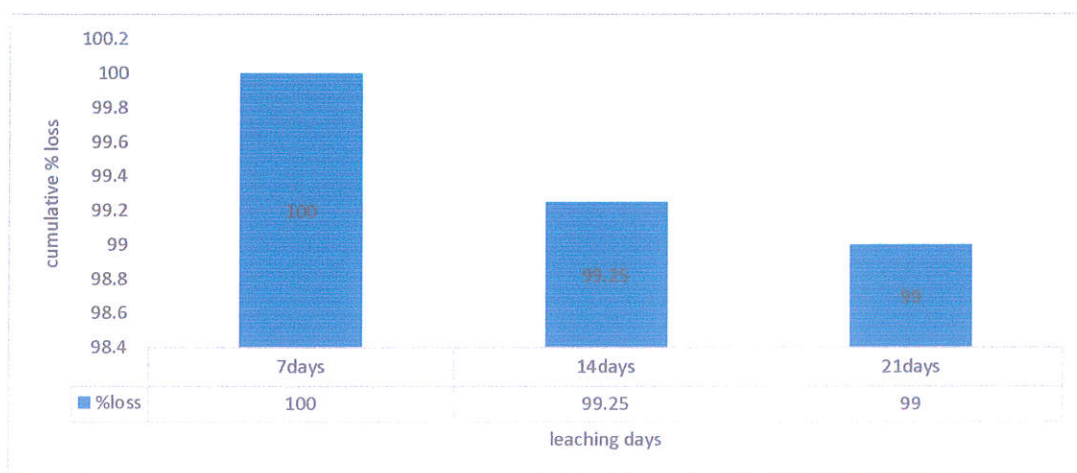| Leaching time	Zinc (ppm)	Loss (ppm)	Cumulative % loss
7days	150.25	0	100
14days	149.50	0.75	99.25
21days	149.25	0.25	99.00

Figure 4.4: Extraction of Zinc in cassava fluid with leaching time (days)

The Figure 4.4 shows that the zinc obtained from the atomic absorption spectrometry (AAS) is decreasing with respect to the days of leaching process likewise cumulative % loss. This result shows that at 7days, 14days and 21days; 150.25, 149.50 and 149.25 of zinc was dissolved respectively in the cassava leave extract that was used to digest the roasted ore. The cumulative % loss shows the progressive rate at which the lead is decreasing with respect to the leaching time (days). Hence it is advisable to reduce the days of leaching because the cyanide is more active at the early days of leaching, also before the grow of Pseudomonas Sp. which reduces the cyanide content in the cassava extract (A Akcil, et al.,) with also consuming the Zinc that should

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be produced. Meta-bromo-thiolactone(Mbtl) (O'loughlin CT et al.,) could be added to render inactive the presence of Pseudomonas Sp. during the bioleaching process.

Table 4.6   Result of extraction of Pb from ore using cassava fluid extract

Leaching time	Lead extraction (ppm)	Gain (ppm)	Cumulative % Gain
7days	55.25	0	100
14days	62.25	7.00	93.00
21days	79.25	17.00	76.00
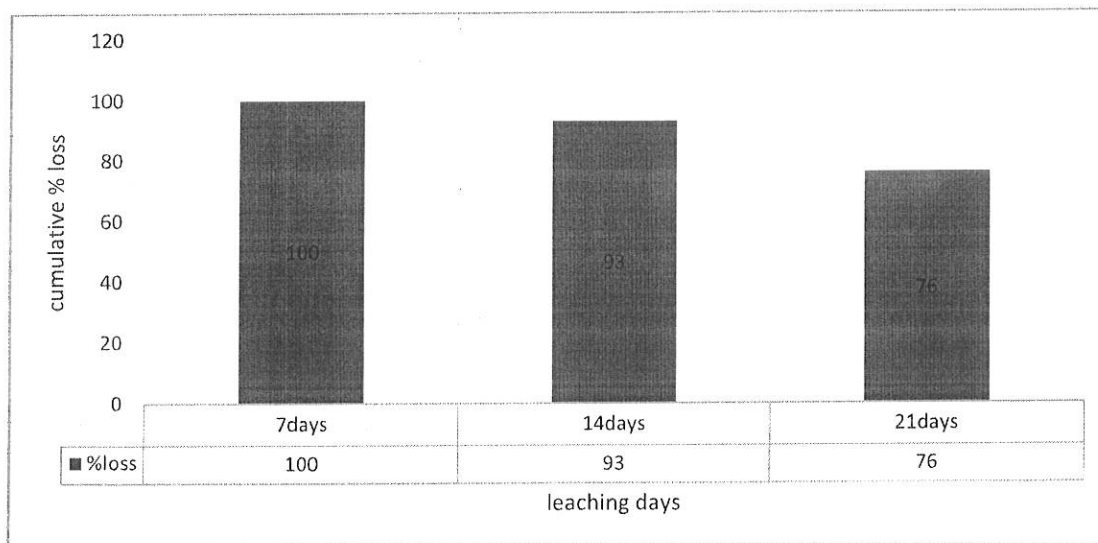
Figure 4.5: Extraction of lead in cassava fluid with leaching time (days).

The Figure 4.5 shows that the lead obtained from the atomic absorption spectrometry (AAS) is increasing with respect to the days of leaching process likewise cumulative % loss. This result shows that at 7days, 14days and 21days; 55.25, 62.25 and 79.25 of lead was dissolved respectively in the cassava leave extract that was used to digest the roasted ore. The cumulative % gain shows the progressive rate at which the lead is increasing with respect to the leaching

time (days). Hence it is advisable to increase days of leaching since the Pseudomonas Sp. present don't consume the lead that are produced.

Table 4.7   Result of extraction of Fe from ore using cassava fluid extract

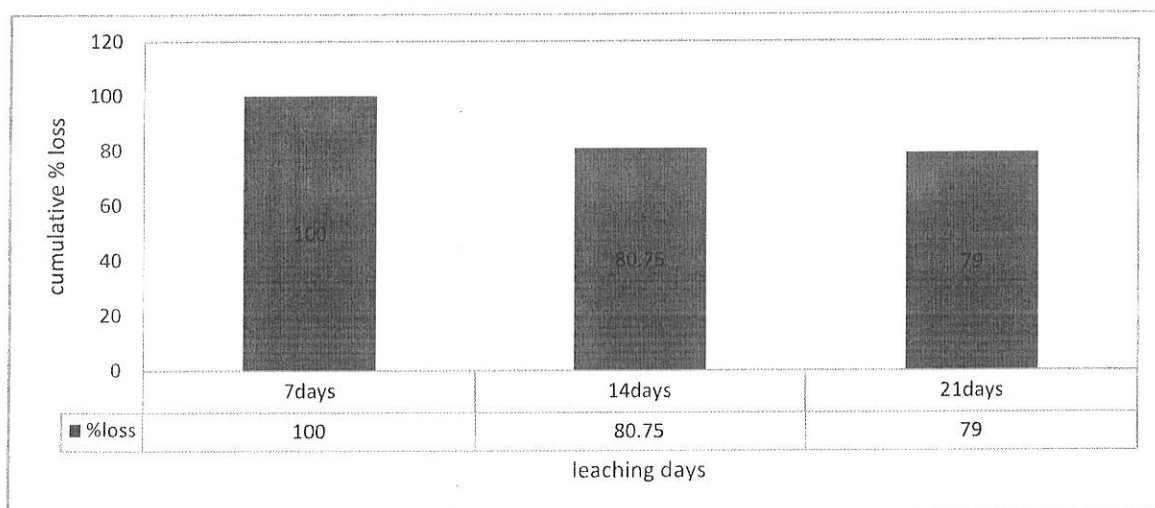| Leaching time	Iron (ppm)	Loss (ppm)	Cumulative %loss
7days	25.25	0	100
14days	6.00	19.25	80.75
21days	4.25	1.75	79.00

Figure 4.6: Extraction of Iron in cassava fluid with leaching time (days)

The Figure 4.6 shows that the iron obtained from the atomic absorption spectrometry (AAS) is decreasing with respect to the days of leaching process likewise cumulative % loss. This result shows that at 7days, 14days and 21days; 25.25, 6.00 and 4.25 of iron was dissolved respectively in the cassava fluid extract. The cumulative % loss shows the progressive rate at which the iron is decreasing with respect to the leaching time (days). Hence it is advisable to reduce the days of leaching because the presence of Pseudomonas Sp. reduces the cyanide content in the cassava

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extract(A Akcil, et al.,) this bacterial also consume the iron that should be produced. Meta-bromo-thiolactone(Mbtl) (O'loughlin CT et al.,) could be added to reduce or make inactive the presence of Pseudomonas Sp. which consume the cyanide content in the leachant.

Table 4.8   Result of extraction of Cu from ore using cassava fluid extract

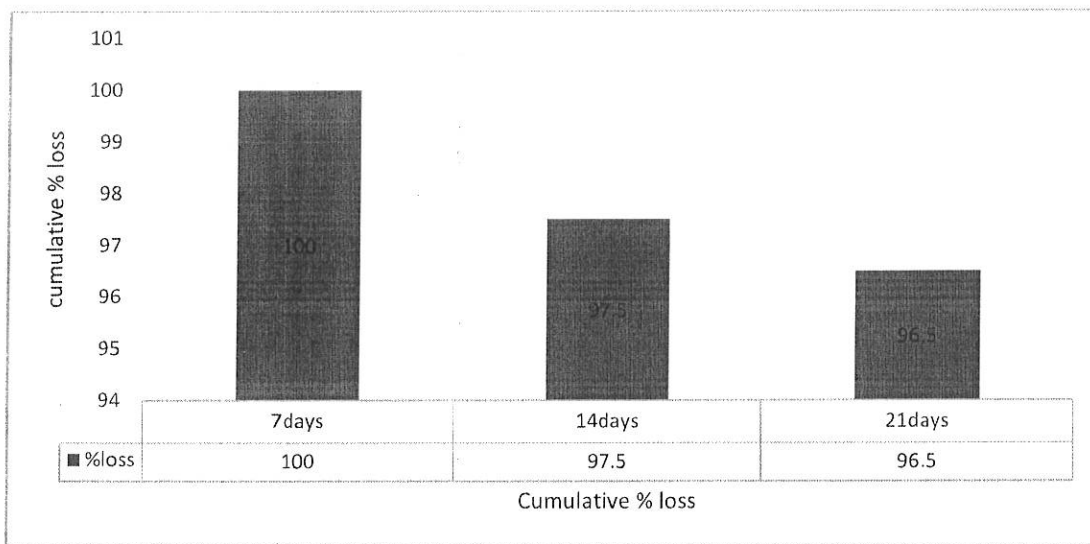| Leaching time	Copper (ppm)	Loss (ppm)	Cumulative %loss
7days	3.75	0	100
14days	1.25	2.50	97.50
21days	0.25	1.50	96.50

Figure 4.7: Extraction of Copper in cassava fluid with leaching time (days)

The Figure 4.7 shows that the copper obtained from the atomic absorption spectrometry (AAS) is decreasing with respect to the days of leaching process likewise cumulative % loss. This result

shows that at 7days, 14days and 21days; 3.75, 1.25 and 0.25 of copper was dissolved respectively in the cassava leave extract that was used to digest the roasted ore. The cumulative % loss shows the progressive rate at which the Copper is decreasing with respect to the leaching time (days). Hence it is advisable to reduce the days of leaching because the presence of the Pseudomonas Sp bacterial consume the cyanide content in the leachant and also reduces the copper that should be produced. Meta-bromo-thiolactone(Mbtl) (O'loughlin CT et al.,) could be added to reduce or make inactive the presence of the Pseudomonas Sp. with consume the cyanide content.

CHAPTER FIVE

5.0   CONCLUSION AND RECOMMENDATION

5.1   CONCLUSION

From the result of the work carried out on the bioleaching of zinc in agro cyanide with the influence of biochemical agent, it was found that zinc and other related metals such as lead, copper and iron can be extracted using the cassava extract as shown in the result of the Atomic Absorption Spectrometry (AAS) analysis. Bioleaching extraction process produce a more zinc and lead as compared with the results obtained from the use of inorganic leaching reagent previously reported in the literature.

5.2   RECOMMENDATION

It would be recommended that the bioleaching process should be adopted in the industry since the raw materials needed to execute the project is largely valuable in the environment and it yield a better result by producing larger amount of zinc and lead. Also that the bioleaching process should be thought in the curriculum also side the inorganic process of extraction and more facility should be made available to encourage the interest of the student.

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APPENDIX

Calculation under froth floatation

Calculation for concentrate

$\frac{357}{1000} \times 100 = 35.7\%$

Calculation for tailings

$\frac{595}{1000} \times 100 = 59.5\%$

Calculation for loss

$\frac{48}{1000} \times 100 = 4.8\%$

Calculation under roasting

$\%\text{Volatile matter} = \frac{\text{Wt loss (g)}}{\text{Initial wt (g)}} \times 100$

$\%\text{Volatile matter} = \frac{21.48}{250} \times 100$

$\%\text{Volatile matter} = 8.99\%$

Calculation sample for result of extraction of element from ore using cassava fluid extract

Leaching time	Element	Loss(ppm)	Cumulative % loss
7days	a_1	$b_1 = 0$	$c_1 = 100 - b_1$
14days	a_2	$b_2 = a_2 - a_1$	$c_2 = 100 - (b_1 + b_2)$
21days	a_3	$b_3 = a_3 - a_2$	$c_3 = 100 - (b_1 + b_2 + b_3)$